Hardware Manual

UPS-Charger

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Technical Specifications

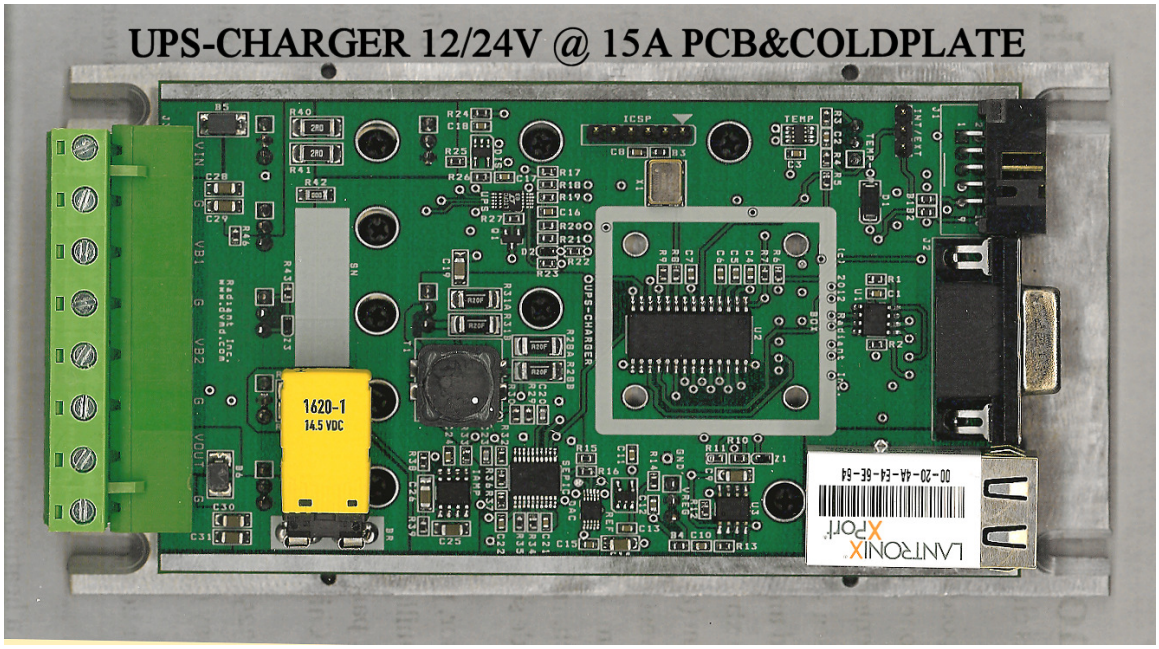
Vendor
Radiant Inc. http://www.dvmd.com

Part Number
901-003

Operating Temperature Range
-40C - +75C.

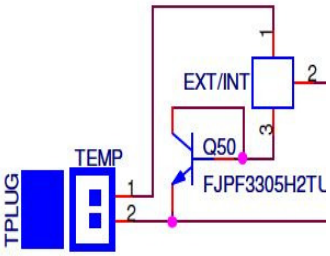
Hardware

UPS-Charger PCB
The image below shows the top view of the PCB. The cold-plate dimensions are 5.75” x 3.3”.



Internal/External Temperature Selector
The three-pin header “INT-EXT” connector is shown in the top right corner of the image above. The INT/EXT pins select the source for the external temperature sensor. When this connector is jumpered to “INT” the temperature of the cold-plate is monitored. The temperature of the cold-plate is available in the TEMPE variable in the status string.

When this connector is jumpered to “EXT” an NPN transistor must be connected to J1, the 10-pin header, in accordance to the diagram at the right. The transistor must be in thermal contact with the external temperature to be monitored. The schematic shows the NPN transistor (Q50) we used in the UPS controller design. This same configuration should be used in an external probe.

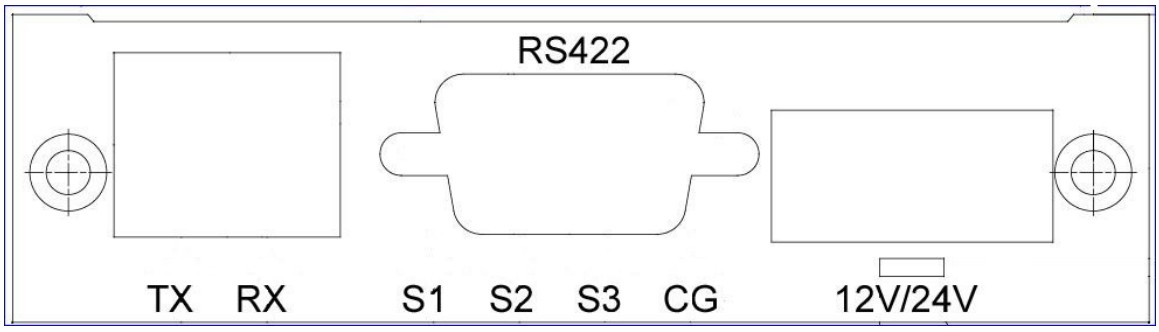


In the EXT position the user must connect an External Temperature Probe containing a diode to the DXP and DXN pins on J1, the 10-Pin Connector. The EXT function allows monitoring the temperature of external batteries or battery packs that are not in the same thermal environment at the UPS controller.

Inside the external temperature probe is an NPN transistor with the base shorted to collector as shown in the drawing of Q50 above.

We have designed several sizes of probes using stainless steel tubes and thermally conductive epoxy. Please contact Radiant for more information.

Front Panel
The front panel shown below contains the optional Network connector (RJ45), RS422 connector (DB9) and a 10-pin header. A slide switch mounted under the 10-pin connector provides battery voltage selection. The LEDs under the NETWORK connector show transmit and receive data activity. The four LEDs under the RS422 connector show the 3 charge states and the Charge-Active state.



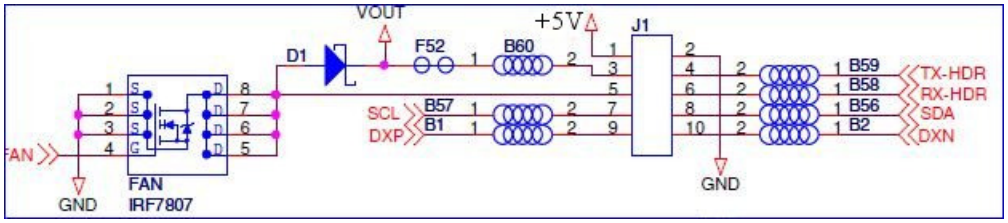
NETWORK CONNECTOR (XPORT)
The Network connector is a Lantronix XPORT that provides 10/100M connectivity to the device. The same serial data stream is available on the RS422 connector.

RS422 CONNECTOR (DB9 Female)
The RS422 connector is a female DB9 that will plug directly into a Sintec model STM422. This small and inexpensive RS422 to RS232 converter provides connectivity to standard PC serial ports. The pins for the 10 pin header and the DB-9 connector are listed in the table below:

PIN	LABEL	DIRECTION	FUNCTION
1	DI-	INPUT	DATA INPUT MINUS
2	DI+	INPUT	DATA INPUT PLUS
3	DO+	OUTPUT	DATA OUTPUT PLUS
4	DO-	OUTPUT	DATA OUTPUT MINUS
5	GND	GND	GROUND
6	+5V	PWR	+5V to power RS422-RS232 converter
7	NC		No connection
8	NC		No connection
9	NC		No connection

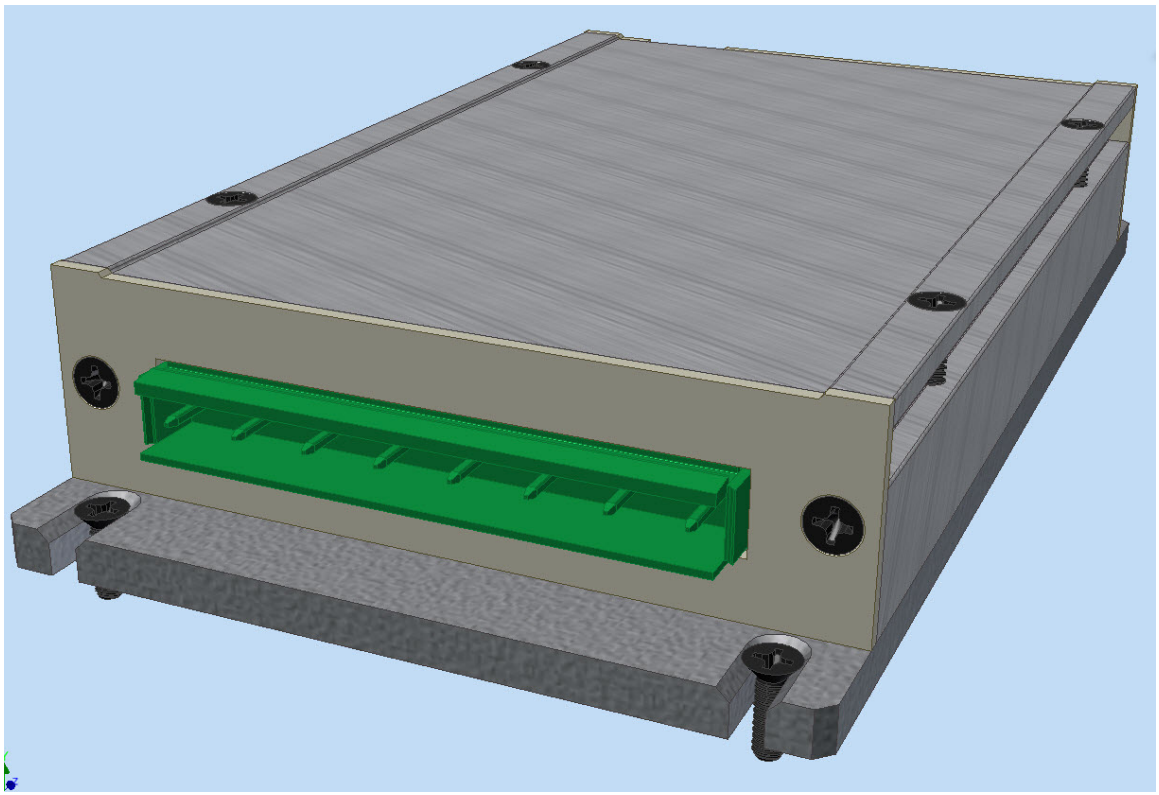
J1: 10-PIN CONNECTOR (IDC)
J1 is a 10-PIN male shrouded header that allows the UPS-Charger to connect directly to the user equipment. This provides a serial port (at 5V levels), and an I2C bus for polling external IO expander. The external temperature sensor are not active unless the jumper is set for EXT inside the product.

PIN	LABEL	DIRECTION	FUNCTION
1	+5V	POWER	POWER
2	GND	GROUND	GROUND RETURN
3	VOUT	OUTPUT	POWER (SWITCHED WITH LOAD)
4	TX-HDR	OUTPUT	DATA OUTPUT (5V UART LEVEL)
5	FAN	OUTPUT	FET SWITCH FOR FAN
6	RX-HDR	INPUT	DATA INPUT (5V UART LEVEL)
7	SCL	OUTPUT	I2C CLOCK
8	SDA	I/O	I2C DATA
9	DXP	INPUT	EXT TEMPERATURE POSITIVE
10	DXN	INPUT	EXT TEMPERATURE NEGATIVE

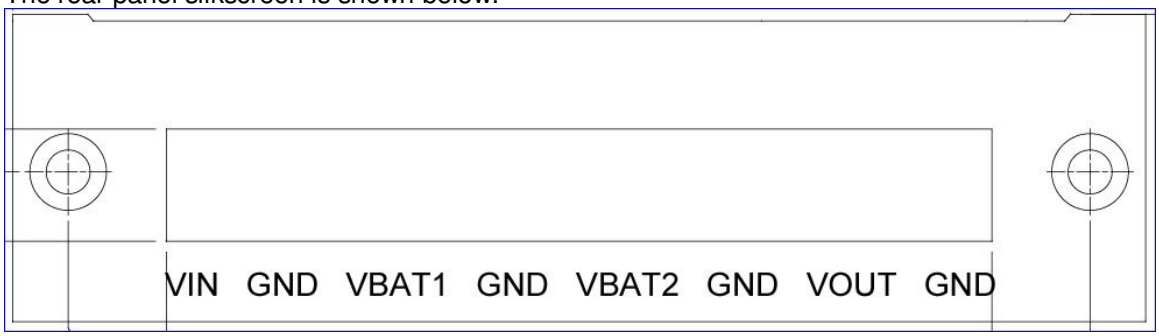


Battery Voltage Selector
This micro slide switch provides battery voltage selection. When the switch is in the 12V position the controller will provide the correct charge profile for 12V lead-acid batteries. When it is in the 24V position the controller will charge 24 volt lead-acid batteries.

REAR-PANEL
A 3-D CAD view of the UPS-Charger rear panel is shown below.



The rear panel silkscreen is shown below.



Power Conditioning (All)
The inputs (VIN, VBAT1, VBAT2) and output (VOUT) are clamped to 29V with 3,000 Watt high-speed Transient Voltage Protector and are filtered with a high power beads and high voltage capacitors to reduce conducted EMI to end-user equipment.

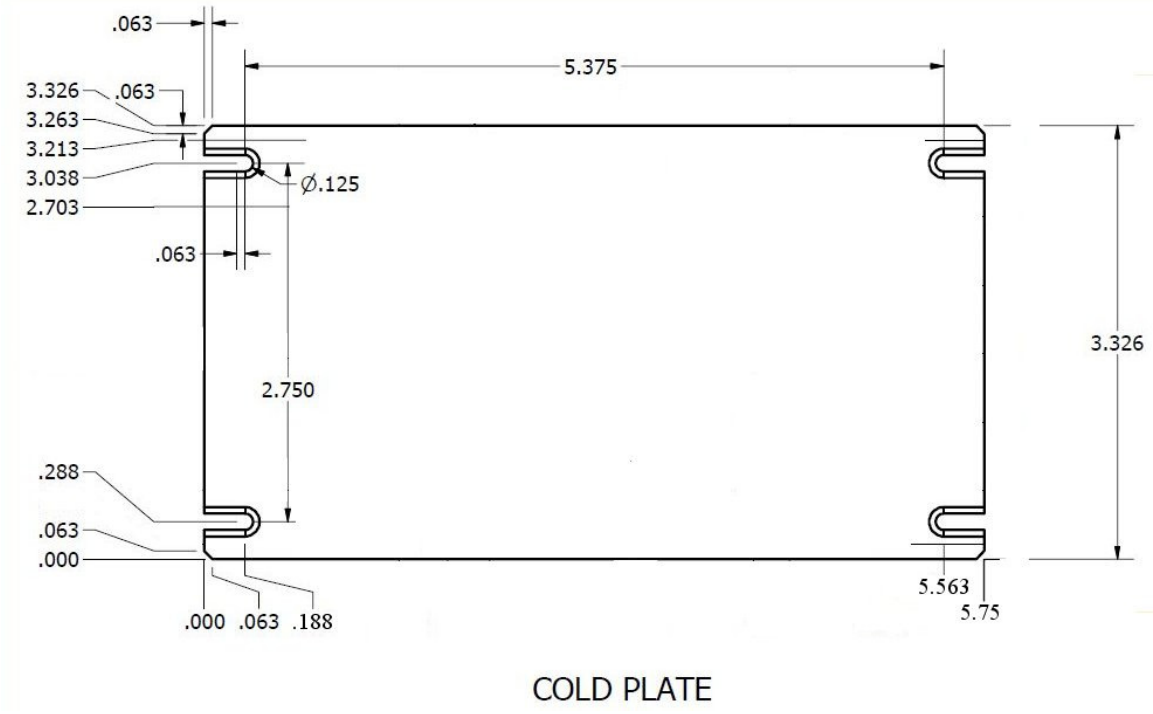
VIN (DC Power Input)
Power enters the UPS-Charger on terminals pins 1 & 2. The valid input voltage range is 10.8 to 29 Volts. The input is polarity protected from reversed leads from the power supply.

VBAT1
Connect a 12V lead-acid battery to the two screw terminals labeled VBAT1 and GND. The battery input voltage range is zero to 28 Volts and is polarity protected from reversed leads to the battery. This input is in parallel with the VBAT2 input below. The first firmware release only supports 12V lead-acid batteries.

VBAT2
Connect a 12V lead-acid battery to the two screw terminals labeled VBAT2 and GND. The battery input voltage range is zero to 28 Volts and is polarity protected from reversed leads to the battery. This input is in parallel with the VBAT1 input above. The first firmware release only supports 12V lead-acid batteries.

VOUT
Connect the load to the two screw terminal labeled VOUT and GND. These terminals provide UPS power to the load. The load can be 0 to 10 amps and can have transients > 15A for a few seconds. The load output voltage range is zero to 28 Volts and is polarity protected from reversed polarity due to the polarity protection on both DC power inputs.

CAD Drawing for Heat Sink with Mounting Screw Pattern
The four 4-40 screw pattern is shown below. The cold-plate mounts on a **2.75" x 5.5"** rectangular hole pattern. These holes may be tapped or fitted with with 4-40 press-nuts.



COLD PLATE

Normal Operational States

The local processor is in charge of managing the power to the load, operating the SEPIC battery charger, and handling the various error conditions that can arise. Under normal conditions the local processor sequences through the following states:

DELAY State

The DELAY state monitors the DC Voltage input and waits until it is > 11 volts for ten seconds. This avoids turning power on to the load during AC/DC transients that may occur during power on or switching between main power and AC Generators.

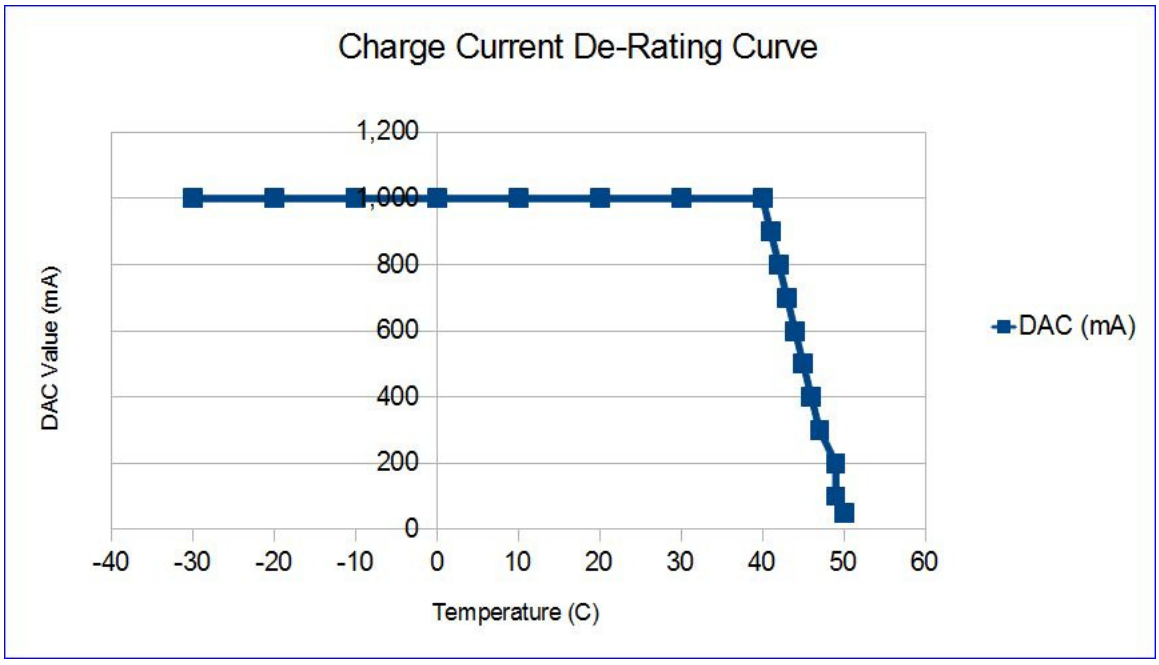
PON State

The PON state powers the load from both the DC Power Supply and the Battery input for 50 seconds. Connecting both the DC input and the Battery to the load allows for the starting of high-current loads for 45 seconds. The extra power allows PTZ cameras to go through the HOME sequence with minimum voltage droop during the time of high motor current. During the last 5 seconds of the ON state the Battery is placed on standby and the DC Power Supply is connected to the load. If excessive current conditions still exist the controller will immediately enter the UPS state without loss of power to the load. See the UPS state below.

Charger De-Rating Curve

The last three charge states are modified to reduce the charge-current as necessary to maintain the DC Supply voltage above 11 volts. They ramp the charge current from zero *towards* 1 amp in 25 mA increments each second. Each second they monitor the DC Input voltage to verify that it does not fall below 11 volts. If the DC Input voltage falls below 11 volts they *reduce* the charge current by 25 mA. The charge current is reduced from 1000mA (Maximum) down to 50mA (Minimum) as the cold-plate temperature rises from 40C to 50C. The curve below illustrates the de-rating of the charge current versus temperature. Even above 50 degrees Celsius a 50 milliamp charge current is available to maintain the float voltage if needed.

Lead-acid batteries should not be charged at temperatures higher than 50C. All charging at elevated temperatures incur risk of overheating the battery and causing the internal pressure to rise above the safety value set by an embedded one-way discharge over-pressure valve. If this valve ever activates the lifetime of the battery is severely diminished.



Charger States

Under normal conditions the SEPIC Charger sequences through the following states:

TKL State

The TKL state is used when the battery voltage is too low for bulk charging. This state first checks to see if a battery is connected. If the Battery voltage is greater than 8 volts but less than 10 volts the TKL state trickle-charges the battery at 250 mA. The length of time that the TKL state is operational is from 1 second to continuous.

If the Battery voltage falls below 7.5 volts during the TKL state it re-enters the PON state above.

CCM State
The CCM state is a modified Constant Current charging cycle. This state is used to provide the bulk-charge to the battery. For properly sized AC/DC supplies and non-excessive load conditions the charger quickly ramps up the charge current to 1 amp until the temperature compensated target voltage is obtained on the battery terminals.

OVM State
The OVM state is a modified Over Voltage charge cycle. This state over charges the battery by 100mV above the temperature compensated charge voltage. This ensures that the battery is completely charged before entering the float state.

CVM State
The CVM state is a modified Constant Voltage Mode or "Float" charge cycle. This state ensures that the battery is maintained at the temperature compensated terminal voltage over time. Most of the battery life is spent in the CVM state and improper float voltage can cause over-charging, bulging, off-gassing and shorten battery life. The correct float voltage for all temperatures is available to the user in the serial output string documented below. The battery terminal voltage can always be measured with a DVM and compared against the float voltage in the status string.

UPS Hardware and States

UPS Hardware
The UPS hardware detects that the DC Power Supply has dropped below 10.8 volts. When the DC power goes below this threshold the UPS hardware:

1. Switches in the Battery to power load within 5uS. During cross-over the load voltage can sag down to 8 Volts (depending on the load current) before rising up to the battery voltage which is usually around 13.8 volts.
2. Interrupts the local processor so it can switch to the UPS state.

UPS State
The UPS state is the Uninterrupted Power Supply state. This state monitors the DC Supply and the Battery voltage.

1. If the DC Supply voltage returns above 11 volts this state returns to the PON state.
2. When the battery voltage falls below 10.8 volts it turns power off to the load and enters the OFF state.

OFF State
The OFF state turns the power to the load off and monitors both the DC Input voltage and the Battery voltage.

1. If the DC Input Voltage rises above 11 volts the state transitions to PON.
2. If the Battery Voltage drops below 10.7 volts all power is turned off including the power to the local processor and the serial link. The residual current draw is < 1mA.

Error States

EOT State
The Error Over Temperature state occurs when the heat sink temperature is greater than 60 degrees Celsius. This state continues to power the load but turns the charger off. It monitors the heat sink temperature and waits for the heat sink to cool back down under 60 degrees C. When the temperature of the heat sink is less than 60C this state transitions to the PON state.

EBO State
The Error Breaker Open state occurs when the measured voltage across the breaker is greater than 1 volt. Under normal operating conditions the EBO state should never occur because this voltage should be in the range of a few hundred mV depending on load current.

When the breaker opens a small current continues to flow to the load to hold the Positive Temperature Coefficient breaker open.

To accomplish the automatic reset function the EBO state turns off all power to the load and waits for 1 minute. After that time this state transitions to the DLY state which attempts to restart the load in the normal fashion.

If the over current condition persists the breaker will trip again which will again be detected and result in re-entering the EBO state. The delay time is doubled each time the EBO state is entered. The delay time is increased until it hits a 30 minute ceiling. After that the EBO state attempts to restart the load every 30 minutes.

Restarting a dead shorted load stresses the breaker and reduces the lifetime which is rated at 300 cycles. The 300 cycle number is for breaking very large current discharges. The number of break cycles at lower (10-15 amp) over current situations is unknown.

Over current situations can occur in winter with 12V heaters installed in the camera housing. As the temperature increases the heater duty cycle increases until it is “on” all the time. This can cause the breaker to trip even when the current slightly exceeds the breaker rating. See the breaker curve below.

PTC Breaker

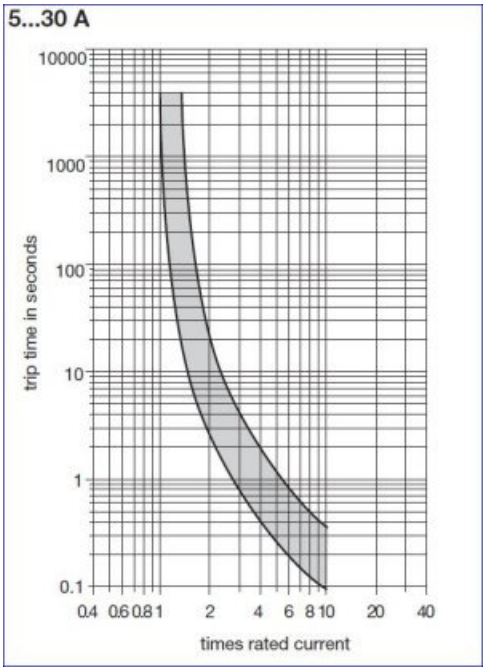
There is an automotive 15-amp Positive Temperature Coefficient Fuse on the top of the controller that opens when the current draw exceeds 15 amps for more than 1 second.

During overload or shorted load conditions the breaker opens with an audible click. It stays open due to self-heating of the PTC material as long as power is applied.

The local processor detects when the breaker is open and turns power off to the load. When the power is turned off the self-heating is discontinued and the breaker resets; also with audible click.

The local processor waits for 1 minute for the breaker to cool. It then attempts to restart the load. If the breaker opens again the delay time is doubled. This process continues until the delay time reaches 30 minutes. The system will attempt repeated restarts every 30 minutes until the overload or short is removed.

PTC Breaker Curve



These fuses are rated for 300 OPEN cycles at <=50 Amps. There were no failures after hundreds of cycles breaking a 20 amp load and a dead short. However extended operation at overload conditions will eventually damage the breaker. If the breaker is damaged it must be replaced after the over current condition is removed.

Fan

The FAN output is on the J1 connector. The FAN N-FET is turned on whenever the heat sink temperature is greater than 50 degrees Celsius. This is not a separate state but is indicated in the F field of the "FI" output string. Normally the FAN is off and the value of "F" is "0". When the FAN is on the value under the F column changes to a "1".

Functions Common to All States

All states do the following common tasks:

Monitor Battery Current

All states monitor the charge/discharge current to the battery. The current firmware measures the current to plus/minus 15 amps at +/- 10% accuracy.

Report Serial Data

All states send a status string to the RS422 output at 9600 baud, 8 bits, no parity, no flow control. A constant length data packet delimited with STX and ETX shows the state machine status.

Timekeeping

All states maintain the time since the state was entered in Day/Hour/Min/Sec format.

Under Voltage Disconnect (UVD)

The DC power input and/or the battery is connected via a UPS controller to the load. If the AC power fails the battery provides the power to the load. When the battery voltage drops to 10.8V the load is disconnected from the battery.

Note that the battery voltage jumps up about 1 volt when the load is disconnected. After the load is turned off there is usually plenty of power left in the battery to maintain the local processor and a low power serial link for hours or days.

The local processor holds power on to itself and provides user feedback on the conditions of the UPS each second until the battery voltage drops to 10.7 volts. The time that the processor runs after the main load is disconnected is determined by the size of the battery and the 25mA current required by the local processor. This time is usually > 10 hours and can easily be many days.

Future States

Remote Power Control
The user will be able to send a serial command to the controller to remotely turn the power on and off to the load. This is not implemented in Version 1.0 of the firmware.

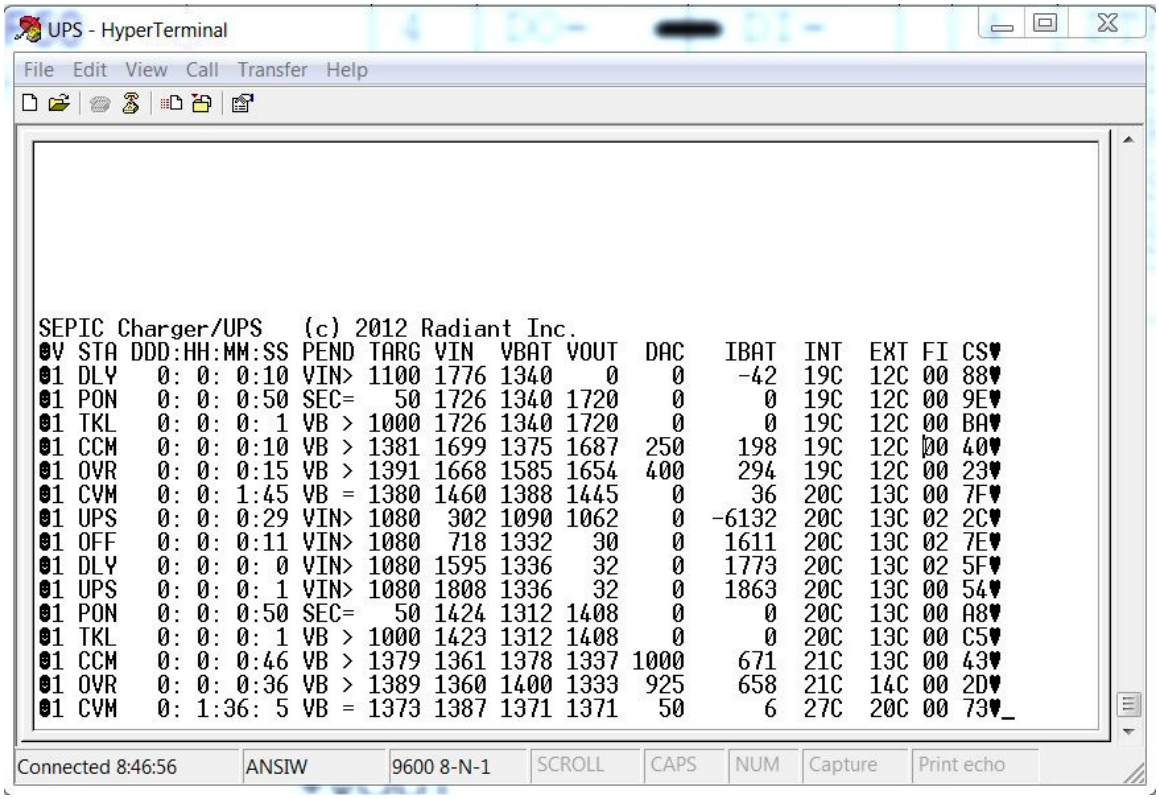
Remote Battery Discharge
The user will be able to send a serial command to the controller to remotely discharge the battery. When the discharge command is received the controller discharges the battery at the user-specified current level until the voltage on the battery drops below 10.8V. At 10.8V the discharge cycle is terminated and the normal charge cycle begins. This is not implemented in Version 1.0 of the firmware.

Appendix A: Graphical User Interface

A screen shot of the Graphical User Interface (GUI) appears below. This GUI appears in any terminal program. In the case below we have configured Hyper Terminal to COM 4 at 9600 baud, 8-bits, no parity. This output log starts with the sign on UPS-Charger © 2012 Radiant Inc. that appears when the local processor boots. This happens at power on or when the manual reset button is pressed. The first character is STX and the last character is ETX. They are denoted differently for each terminal program. Hyper Terminal uses a “smiley face” and “valentine”. The STX character is followed by the status string:

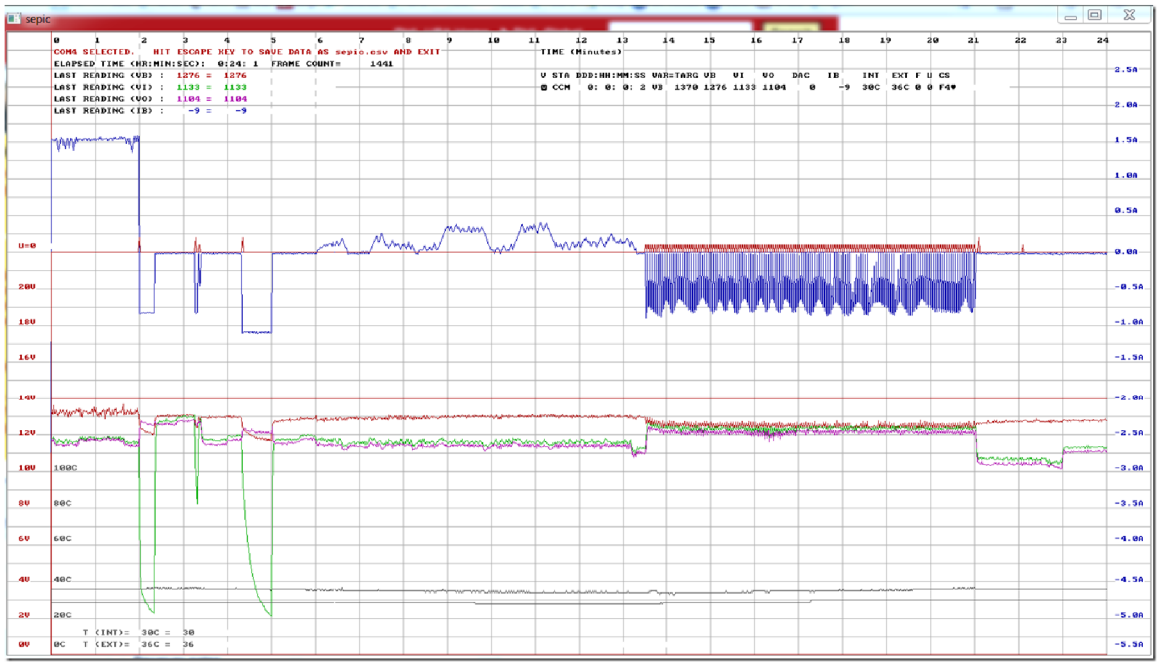
V STA DDD:HH:MM:SS PEND TARG VIN VBAT VOUT DAC IBAT INT EXT FI CS

V:	**Version:** Version 1 is shown below. This can only be changed by in-circuit re-programming
STA:	**State:** The various states are denoted by three characters
DDD:	**Day:** The days range from 0 to 999 (duration of each state)
HH:	**Hour.** The hours range from 0 to 23 (duration of each state)
MM:	**Minutes:** The minutes range from 0 to 59 (duration of each state)
SEC:	**Seconds:** The seconds range from 0 to 59 (duration of each state)
PEND:	**Pending Variable:** Shows what each state is pending on before it can proceed
TARG:	**Target:** Numerical target for the pending variable
VIN:	**Voltage In:** This is the Input DC Supply Voltage 1776 is 17.76 volts
VBAT:	**Voltage Battery:** This is the battery terminal voltage 1340 is 13.40 volts
VOUT:	**Voltage at Output:** This is the voltage to the load voltage 1720 is 17.20 volts
DAC:	**D/A decimal value:** This is the charger DAC value current command
IBAT:	**Measured Battery Current:** Battery charge/discharge current in mA
INT:	**Internal Temperature:** This is the temperature of the PCB in degrees Celsius
EXT:	**External Temperature:** Temperature of the Heat-sink or optional external temp probe
V:	**Voltage Setting:** Set by slide switch 0 indicates 12V and 1 indicates 24V
F:	**Fan:** Shows fan on/off state. If this is a “1” the optional FAN is on. Normally < 50C this is a zero.
I:	**Interrupt Level:** If this is a “1” the hardware detected a UPS event If this is a “2” the hardware detected an over-current
CS:	**Checksum:** This is a 2's complement check sum to verify packets are OK


UPS - HyperTerminal
File Edit View Call Transfer Help
SEPIC Charger/UPS (c) 2012 Radiant Inc.
@V STA DDD:HH:MM:SS PEND TARG VIN VBAT VOUT DAC IBAT INT EXT FI CS♥
@1 DLY 0: 0: 0:10 VIN> 1100 1776 1340 0 0 -42 19C 12C 00 88♥
@1 PON 0: 0: 0:50 SEC= 50 1726 1340 1720 0 0 19C 12C 00 9E♥
@1 TKL 0: 0: 0: 1 VB > 1000 1726 1340 1720 0 0 19C 12C 00 BA♥
@1 CCM 0: 0: 0:10 VB > 1381 1699 1375 1687 250 198 19C 12C 00 40♥
@1 OVR 0: 0: 0:15 VB > 1391 1668 1585 1654 400 294 19C 12C 00 23♥
@1 CVM 0: 0: 1:45 VB = 1380 1460 1388 1445 0 36 20C 13C 00 7F♥
@1 UPS 0: 0: 0:29 VIN> 1080 302 1090 1062 0 -6132 20C 13C 02 2C♥
@1 OFF 0: 0: 0:11 VIN> 1080 718 1332 30 0 1611 20C 13C 02 7E♥
@1 DLY 0: 0: 0: 0 VIN> 1080 1595 1336 32 0 1773 20C 13C 02 5F♥
@1 UPS 0: 0: 0: 1 VIN> 1080 1808 1336 32 0 1863 20C 13C 00 54♥
@1 PON 0: 0: 0:50 SEC= 50 1424 1312 1408 0 0 20C 13C 00 A8♥
@1 TKL 0: 0: 0: 1 VB > 1000 1423 1312 1408 0 0 20C 13C 00 C5♥
@1 CCM 0: 0: 0:46 VB > 1379 1361 1378 1337 1000 671 21C 13C 00 43♥
@1 OVR 0: 0: 0:36 VB > 1389 1360 1400 1333 925 658 21C 14C 00 2D♥
@1 CVM 0: 1:36: 5 VB = 1373 1387 1371 1371 50 6 27C 20C 00 73♥_
Connected 8:46:56
ANSIW
9600 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Appendix B: Graphing Software

The UPS-Charger serial data contains information on the status of the system. The data in the output string can be attached to a PC running a software program that parses the data and graphs it each second. The software is written in Free Basic and is available to interested customers for free. Contact Radiant for details. The graph below shows the output from the software during testing and is not typical due to the extreme over current situations.


sepic
COM4 SELECTED. HIT ESCAPE KEY TO SAVE DATA AS sepic.csv AND EXIT
ELAPSED TIME (HR:MIN:SEC): 0:24: 1 FRAME COUNT= 1441
LAST READING (VB) : 1276 = 1276
LAST READING (VI) : 1133 = 1133
LAST READING (VO) : 1104 = 1104
LAST READING (IB) : -9 = -9
TIME (Minutes)
V STA DDD:HH:MM:SS VAR=TARG VB VI VO DAC IB INT EXT F U CS
CCM 0: 0: 0: 2 V8 1370 1276 1133 1104 0 -9 30C 36C 0 0 F49
T (INT)= 30C = 30
T (EXT)= 36C = 36

Appendix C: Installation Instructions

The SEPIC UPS/Charger is shipped installed in an anti-static bag. If the controller must be replaced or returned for repair it should be placed back in an anti-static bag immediately after removal from the customer equipment.

1. Turn the AC Power breaker “off”.
2. Disconnect the DC power wires on the 8-pin header
3. Disconnect the BATTERY wires on the 8-pin header
4. Disconnect the LOAD wires on the 8-pin header
5. Remove the four mounting 4-40 screws.
6. Remove UPS-Charger and place it in an anti-static bag.
7. Install the new UPS-Charger with 4 screws.
8. Install the INT/EXT jumper on the new controller to the INT position unless an external temperature probe is used.
9. Reconnect the LOAD wires, BATTERY wires and DC Power wires.
10. Turn on the AC breaker and insure the DC power light turns on.
11. Insure TX LED is blinking each second are on.
12. Watch the LED1, LED2, and LED3 indicators for 10 seconds and insure that the controller enters the PON state (all “ON”)
13. Watch the LEDs and insure that the controller enters the various charge states. All charge states are indicated when the CHG LED is on solidly.
14. Verify the camera goes through the home sequence.
15. If the UPS state occurs during the HOME sequence verify that the state machine recovers from the over-current condition and enters the charge states.
16. When the Camera home sequence succeeds and the power stays on, the load current will drop and allow all the charge states to continue to the final CVM state.
17. During all this time verify that the RS422 transceivers are communicating with the control system.